Appraisal of initial steps towards a V&A framework for India with special focus on water resources

Final report prepared for **INFRAS Consulting Group for Policy Analysis and Implementation**

December 2001

TERI Project Report No. 2001GW43

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Appraisal of initial steps towards a V&A framework for India with a special focus on water resources

Executive Summary

This report examines the linkages between climate change and water resources. It highlights how climate change can aggravate existing pressures on water resources, and describes how ongoing water management interventions can act as adaptation options with multiple socioeconomic benefits.

With enhanced greenhouse warming, temperature and precipitation changes are predicted to have significant effects on the demand, supply and the quality of water, compounding existing pressures. The socioeconomic implications of climate change on the supply and demand for water will depend on the adaptation potential of water management systems. Adaptation measures ahould be economically efficient, environmentally sustainable, and help advance social goals.

The major impact of climate change in arid and semi-arid India is likely to be an acute shortage of water resources associated with significant increases in surface air temperature. Conservation of water used for irrigated agriculture, needs to be given priority attention. Other related options are protection of soil from degradation, introduction of low water-use crops, implementation of groundwater protection programmes. Such options are part of autonomous adaptation, or changes in agriculture, water resources, etc that individuals or communities undertake in order to adjust to past or ongoing changes (whether extreme climatic events or in response to increased demand). Many demand-side interventions (e.g. improving irrigation use efficiency) and supply-side options (e.g. increasing irrigation source capacity) have been implemented or tested within the framework of development activities. These management strategies are also potentially feasible in the face of climate change. Traditional methods for water conservation that have been in use in water-scarce parts of India are suited to the

environments in which they have evolved, and can be encouraged as potential adaptation options that promote conservation as well as efficient utilisation of the resource.

There is a need for an integrated approach to water resources management, which explicitly considers all potential supply-side and demand-side options, includes all relevant stakeholders in the decision-making process, and involves continuous monitoring of the water resources situation. This is a no-regrets approach that would be beneficial even in the absence of climate change, but will further strengthen the capacity to cope with the impacts of climate change.

India should identify and provide detailed information through its national communication on the country's needs and concerns arising from the adverse impacts of climate change. It should also mobilize existing national institutions and build on existing endogenous capacities, traditional skills, knowledge and practices. By identifying its specific V&A capacity building priorities, the country can seek financial support from the funds established under the Bonn agreement, as well as other bilateral and multilateral sources. This approach should involve a wide range of stakeholders, including national and local government bodies, civil society, private sector, and other organizations.

1. Purpose

The purpose of this report is to discuss issues related to vulnerability and adaptation to climate change, with particular reference to water resources in India. It is divided into three broad sections. The first section introduces the issues of climate vulnerability, and discusses geographical differences in climate change impacts in the context of historical contributions to greenhouse gas emissions. It summarizes the status of the Indian government's process of preparing the first national communication, including V&A assessment, and highlights the implications of recent developments in international climate change negotiations for the formulation of adaptation policy. Within this overall context, the second section focuses on the water resources sector in India. It discusses the pressures on this sector, the existing institutional framework, and potential climate change impacts. The final section focuses on adaptation policy and measures. It assesses representative water conservation interventions as adaptation options, highlighting linkages between water resources and other related sectors, and puts forward initial steps to formulate an adaptation strategy in India.

2. Background

2.1 Climate change and water resources

Water is a vital resource that cuts across all sectors in terms of its usage, playing an important role in the social and economic development of a region. Though it is abundantly present, only a small proportion of it is actually available for use in the form of surface and underground running water. Globally, water is becoming an increasingly scarce commodity. Several estimates have indicated that existing amounts of available water might not be able to meet the needs of a much larger population for longer time periods as pressures continue to rise. Hence, increase in rate of consumption due to increasing population and changing lifestyles is a cause for concern for effective sustainable management and utilisation of this resource.

Apart from existing pressures, climate change is expected to worsen existing conditions. The hydrological cycle is likely to be altered due to climate change. Temperature changes

will affect evapotranspiration rates, cloud characteristics, soil moisture, storm intensity, and snowfall and snowmelt regimes in a major way while changes in precipitation will affect the timing and magnitude of droughts and floods, shift run off regimes and alter ground water recharge characteristics (Gleick 1998). The availability of surface water and ground water supply is likely to get affected through increased variability of inflows, evaporation losses, and changes in percolation rates. Several regions that are already under stress in terms of per capita water availability are likely to be severely affected due to climate change in future. Lal (2001) argues that temperature and precipitation changes will have significant effects on the demand, supply and the quality of water. The socioeconomic implications of climate change on the supply and demand for water will to some extent depend on the adaptation potential of water management systems. The Third Assessment Report of the IPCC points out that the greatest vulnerability to climate change will be in unmanaged or unsustainably managed water systems that are currently water stressed (IPCC 2001).

2.2 International comparison of historical contributions to GHG emissions and distribution of potential impacts

Most studies reviewed in the IPCC TAR indicate that developing countries are more vulnerable to climate change than developed countries. This is because their economies rely more heavily on climate-sensitive sectors (e.g. agriculture), which operate close to environmental and climatic tolerance levels (e.g. water resources). If current development trends continue, few developing countries will have the necessary financial, technical, and institutional capacity for efficient adaptation to climate impacts (IPCC 2001). Further, the TAR indicates that at low levels of warming (less than 2-3°C), mixed climate damages are likely to be experienced across regions, whereas at higher levels of warming (more than 2-3°C) most regions have net damages (Table 1).

With regard to specific sectors, there is relatively less known about the regional distribution of impacts. However, examples of studies of coastal areas, water resources, and agriculture reiterate the higher vulnerability and low adaptability of tropical developing countries. For instance, 40-cm sea level rise by the 2080s would lead to

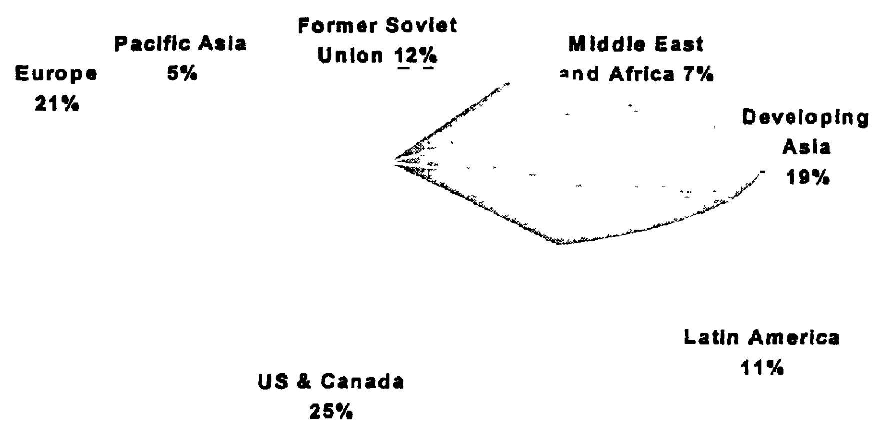
flooding annually of 55 million people in south Asia, 21 million in south-east Asia, and 14 million in Africa, as opposed to only 3 million in the rest of the world (Nicholls et al 1999). In terms of agriculture, climate change is expected to increase yields at higher latitudes and reduce yields at lower latitudes. Beneficial impacts are expected predominantly in the developed world, while strongly negative effects are expected for populations that are less prepared to adapt (due to lack of infrastructure, capital, or education) or are poorly connected to regional and global trading systems (IPCC 2001).

Table 1. Regional distribution of climate impacts (% of current GDP)

Region	IPCC (1996)	Mendelsohn et al (2000)		Nordhaus & Boyer (2000)	Tol (1999)
	+ 2.5°C	+ 1.5°C	+ 2.5°C	+ 2.5°C	+1°C
North America					3.4
– US			0.3	-0.5	
OECD Europe					3.7
– EU				-2.8	
OECD Pacific					1.0
– Japan			-0.1	-0.5	
Eastern Europe/Former USSR					2.0
– Eastern Europe				-0.7	
– Russia			11.1	0.7	
Middle East				-2.0	1.1
Latin America					-0.1
– Brazil			-1.4		
South, southeast Asia					-1.7
– India			-2.0	-4.9	
China			1.8	-0.2	2.1
Africa				-3.9	-4.1
Developed countries	-1.0 to -1.5	0.12	0.03		
Developing countries	-2.0 to -9.0	0.05	-0.17		
World					
– Output weighted	-1.5 to -2.0	0.09	0.1	-1.5	2.3
– Population weighted				-1.9	
– At world average prices					-2.7
– Equity weighted					0.2

Source: IPCC (2001)

Figure 1. Regional contributions to cumulative CO_2 emissions from industrial sources and land use change (1900-99)

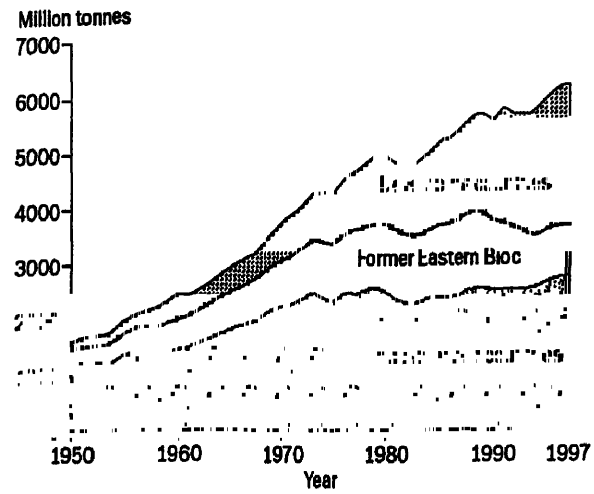


Source: WRI (2001)

Although the countries of the developing world are more vulnerable to climate change, their contribution to the creation of the greenhouse problem has been much smaller than that of developed countries. The impacts of climate change are determined by the extent of temperature rise, which itself is a function of the stock of concentration of GHGs in the atmospheric. Given the long life of GHGs, it is cumulative (and not current) emissions that determine the magnitude of climate change. This cumulative increase in GHG emissions has not been geographically uniform. Historically, developed countries have been responsible for more than 60% of the total global stock of GHGs (figure 1).

The share of developing countries has been increasing only in recent years, as they proceed on the path of development. Figure 2 shows the contributions of industrialized countries, developing countries, and countries of the former Eastern Bloc to carbon emissions from fossil fuel burning over the second half of the 20th century. Despite this increase, current emissions of even large and growing economies like India and China continue to be much lower than those of key developed countries. In per capita terms, India's emissions are far lower than those of the United States, and are a fraction of the world average (Figure 3).

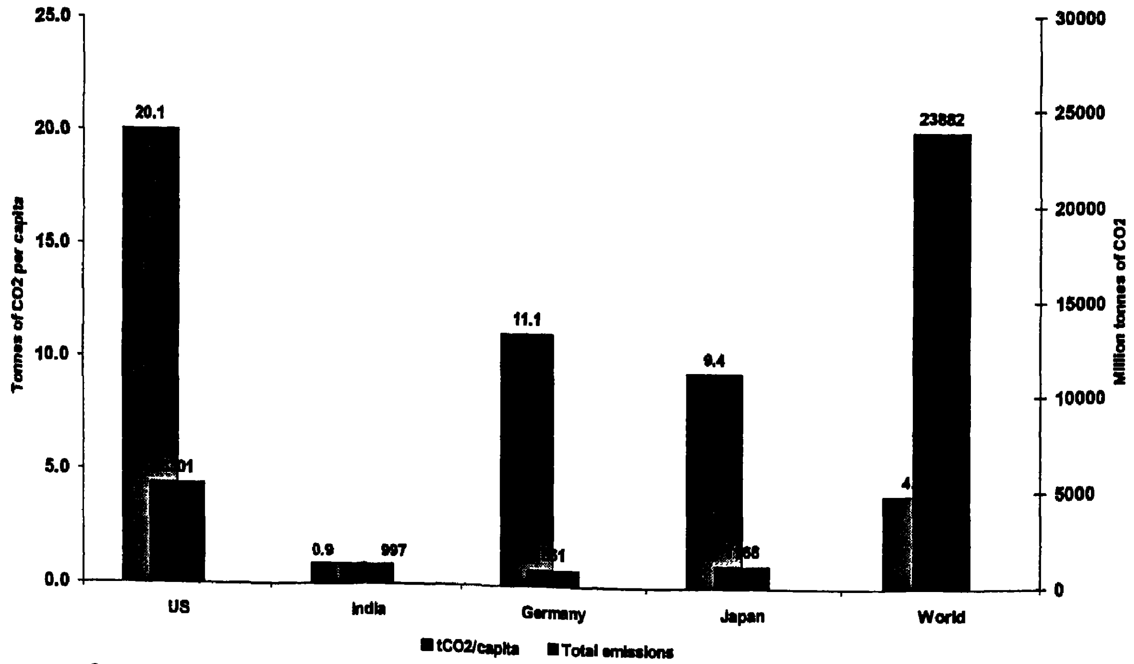
Figure 2. Carbon emissions from fossil fuel burning (1950-97)



Source: Dunn (1998)

In addressing its ultimate objective of stabilizing atmospheric GHG concentrations, the FCCC follows the principles of "common but differentiated responsibilities" and "respective capabilities". It clearly states that, owing to their historical contributions to the accumulated stock of GHGs, and their greater financial and technical capacities, "developed country Parties should take the lead in combating climate change".

Figure 3. Total and per capita CO_2 emissions (1996): international comparison



Source: IEA (1999)

Moreover, the Bonn agreement achieved at the resumed session of the sixth Conference of Parties to the UNFCCC (COP 6b) highlighted that domestic GHG mitigation efforts in developed countries must be conducive towards reducing the differences in per capita emissions between developed and developing countries.

2.3 Recent developments in international climate negotiations: Post-COP 6b perspective

Some of the most significant decisions taken at (COP6b) dealt with the establishment of financing mechanisms for climate change related activities in developing countries.

- An **adaptation fund** was introduced to finance concrete adaptation projects and programmes in developing countries. This is to be financed mainly through 2% of the share of proceeds from CDM projects. In this respect, it is anticipated that the size of this fund would not be very large. However, the Bonn agreement also calls on Annex I Parties to provide additional contributions to the adaptation fund.
- Annex I Party contributions will also be used to establish a **special climate change fund** to finance activities that are complementary to those funded by the Global Environment Facility (GEF). In addition to adaptation activities, this fund will also support technology transfer, programmes and measures in GHG emitting sectors, and diversification of economies that would be adversely affected by GHG mitigation.
- A **least developed country (LDC) fund** has been introduced to support a work programme for LDCs, including national adaptation programmes of action.

While the adaptation fund would be an important source of finance for adaptation activities in developing countries, funding would not be available until the CDM starts generating credits. The other two funds, which have been established under the Convention, would provide finance for adaptation activities starting at an earlier date. India, however, does not qualify for the LDC fund.

The draft decision on capacity building in developing countries was one of the texts that were forwarded to COP-7 for adoption after completion of negotiations at COP 6b. It lays down the framework for capacity building related to developing countries' implementation of the Convention and participation in the Kyoto Protocol. It is intended to serve as a guide for the GEF, multilateral and bilateral organizations in their capacity building activities related to climate change.

FCCC (2001a) emphasizes the crucial importance of capacity building for developing countries that are particularly vulnerable to the adverse effects of climate change, due to:

- Fragile ecosystems
- High population pressure and isolated geographical locations
- Weak economies, low incomes and high poverty levels
- Land degradation and desertification
- Undeveloped meteorological and hydrological services, and water resources management
- Lack of early warning systems for natural disaster management
- Inadequate food security.

In order to address the V&A needs of developing countries, the above funds, GEF, and other bilateral and multilateral sources are required to support the implementation of the following activities:

- Enabling activities for V&A assessment
- Technical training for integrated climate change impact and V&A assessments across all relevant sectors, and environmental management related to climate change
- Enhancement of institutional capacity to integrate adaptation into sustainable development programmes
- Transfer of adaptation technologies
- Pilot or demonstration projects for adaptation planning, assessment, and integration into national policy

- Capacity building for preventive measures and preparedness for climate change related disasters, particularly, for droughts and floods in areas prone to extreme weather events
- Strengthening or establishing early warning systems for extreme weather events
- Implementation of adaptation activities in water resources management, land management, agriculture, health, infrastructure development, fragile ecosystems, and integrated coastal zone management (FCCC 2001b).

2.4 India's first National Communication to the UNFCCC

India is a Party to the United Nations Framework Convention on Climate Change (UNFCCC). India signed this multilateral treaty on 10 June 1992, and was the 38th country to ratify the Convention on 1 November 1993.

According to Article 12.5 of the UNFCCC, a non-Annex I Party is required to submit its initial communication within three years of entry into force of the Convention for that Party, or upon availability of appropriate financial resources. As part of its National Communication, each Party is required to provide a national inventory of anthropogenic emissions by sources and removal by sinks, of all GHGs not controlled by the Montreal Protocol. The reporting Party may also present information on its specific needs and concerns arising from the adverse effects of climate change and/or the impact of the implementation of response measures. The guidelines for the preparation of initial national communications from non-Annex I countries (Decision 10/CP.2) identify ten vulnerability conditions for countries. India meets six of these conditions because it has:

- low-lying coastal areas
- arid and semi-arid areas, forested areas, and areas prone to forest decay
- areas prone to natural disasters
- areas liable to drought and desertification
- areas of high urban atmospheric pollution
- areas with fragile ecosystems, including mountainous ecosystems

India successfully completed negotiations with the Global Environment Facility (GEF) to obtain an appropriate level of funding for activities that would enable it to comply with the Convention's reporting requirements. It has now initiated the process of preparing its first national communication.

The Government of India through the Ministry of Environment and Forests (MoEF) has implemented a project (No. IND/99/G33) on "Preparation of National Communication on Climate Change", which will assist India in submitting its initial national communication and to build capacity to fulfil its commitments to the Convention on a continuing basis. Activities planned under the project include monitoring and measuring emissions related to anthropogenic activities in different sectors, database management and processing, modeling emissions with related parameters, capacity building (including the organization of related training programmes), consolidating individual efforts/ technology utilization, and undertaking integrated impact assessments. The inventory assessment will follow IPCC guidelines and methodologies in order to improve the comparability and validity of the results. 1994 will be considered as the base year for the purpose of the study. The study will also present an assessment of issues related to vulnerability and adaptation to climate change. The areas to be considered for the assessment are:

- future scenarios (socioeconomic, climate, and emissions)
- agriculture
- land use, land use change, and forestry
- natural ecosystems
- coastal zones
- public health
- water resources
- extreme events

The national communication will serve as a comprehensive database providing a foundation for future work and targeted research on climate change in India.

The MoEF has outlined a framework for the execution of the National Communication project, and has adopted a broad-based participatory approach involving all concerned ministries and government departments, research institutions, non-governmental organizations, experts, and scientists. A Project Monitoring Cell (PMC) has been appointed for implementation and coordination of the project. The team comprises a National Project Director (NPD), to be assisted by a National Project Manager (NPM) and two expert consultants. The functions of the PMC include establishment of a data centre, administrative and logistical support, management of funds, etc. The NPM will assist the NPD in the management and implementation of activities related to the project. The NPD and NPM will prepare and compile key project documents apart from cooperating with individuals and organisations involved in the planning process. The NPD will be responsible for overall supervision of the project and will provide guidance to the project team in coordinating related activities. Two expert consultants have also been appointed by the Ministry to assist the NPM in providing technical inputs to the thematic and planning groups in preparing the progress reports. They will also assist in the dissemination of material and information, help organise workshops, meetings and consultations under the project. The PMC is located at Winrock International India, New Delhi, and various lead and collaborating institutes have been identified for undertaking the different components of the national communication. One of the key institutes involved in the V&A assessment is Jadavpur University, West Bengal.

3. Water resources in India

3.1 Multiple pressures and sectoral inter-linkages

Figure 4 provides a schematic representation of the multiple climatic and non-climate pressures on water resources in developing countries. Factors such as population growth, urbanization, industrialization, and growing agricultural demand adversely affect water availability and quality. This leads to negative impacts on a range of economic sectors, including agriculture, forestry, industry, energy, reservoirs, household use, and health. Climate change acts as an additional force that compounds these negative effects through temperature rise, changes in precipitation patterns, extreme events, and sea level rise.

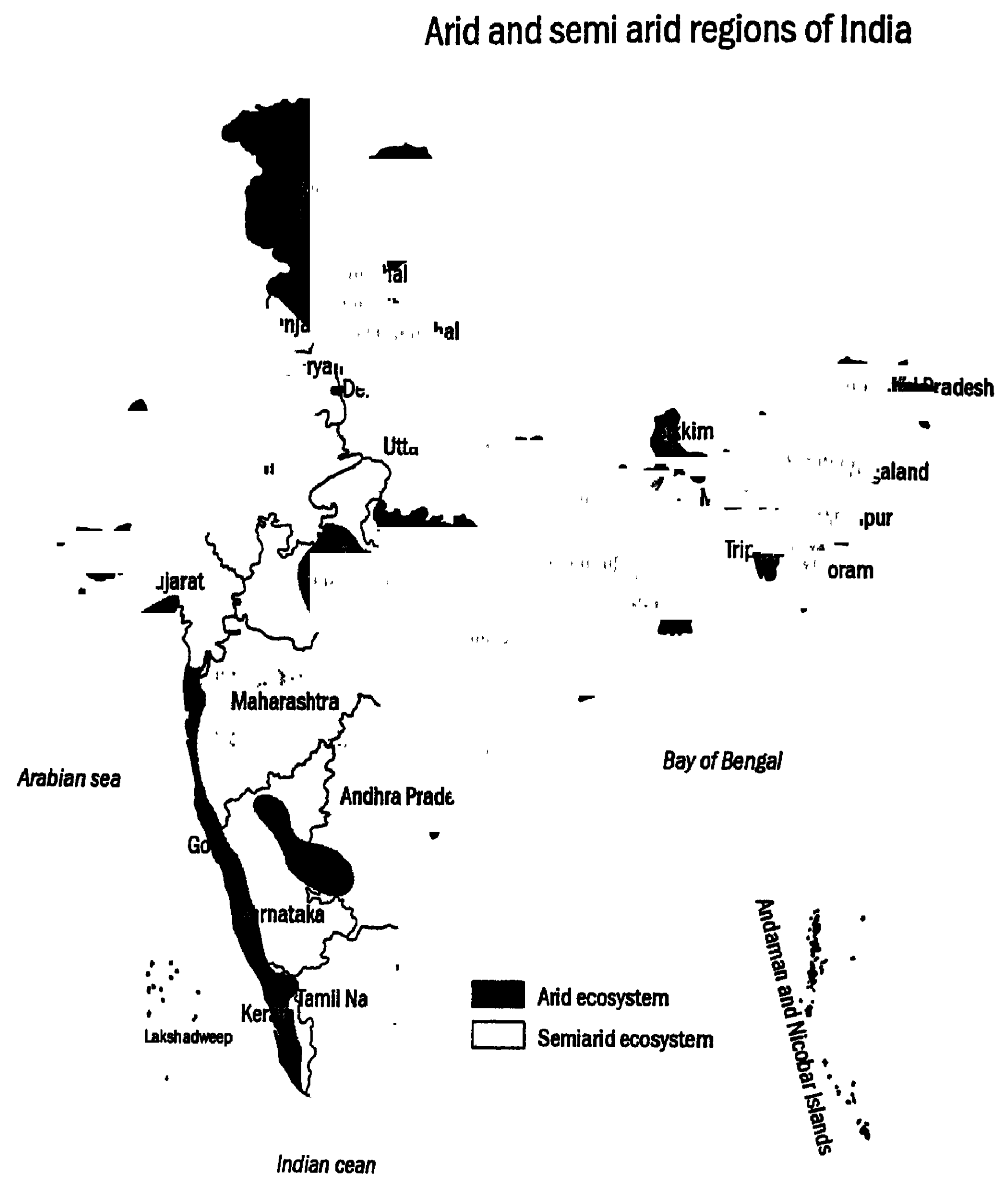


Figure 5. **Arid and semi-arid regions of India**

Source: Velayutham et al (1999)

India is among the countries whose annual renewable water supply exceeds 1000 cubic kilometres. However, physiographic and topographic conditions, inter-state issues, and the existing state of technology to economically harness water resources act as limiting factors to the use of the country's estimated water potential. Although large river basins like the Brahmaputra basin contribute 629 billion cubic metres of surface water, only 21 billion cubic metres i.e., 3.33 % of water is provided in utilisable form (Environment and Water India 2000 Conference). There are large variations in the availability of water

across the country, with some regions facing acute shortages. Regions that lie in arid and semi-arid areas of the country (Figure 5) are already facing water stress due to prevailing natural conditions.

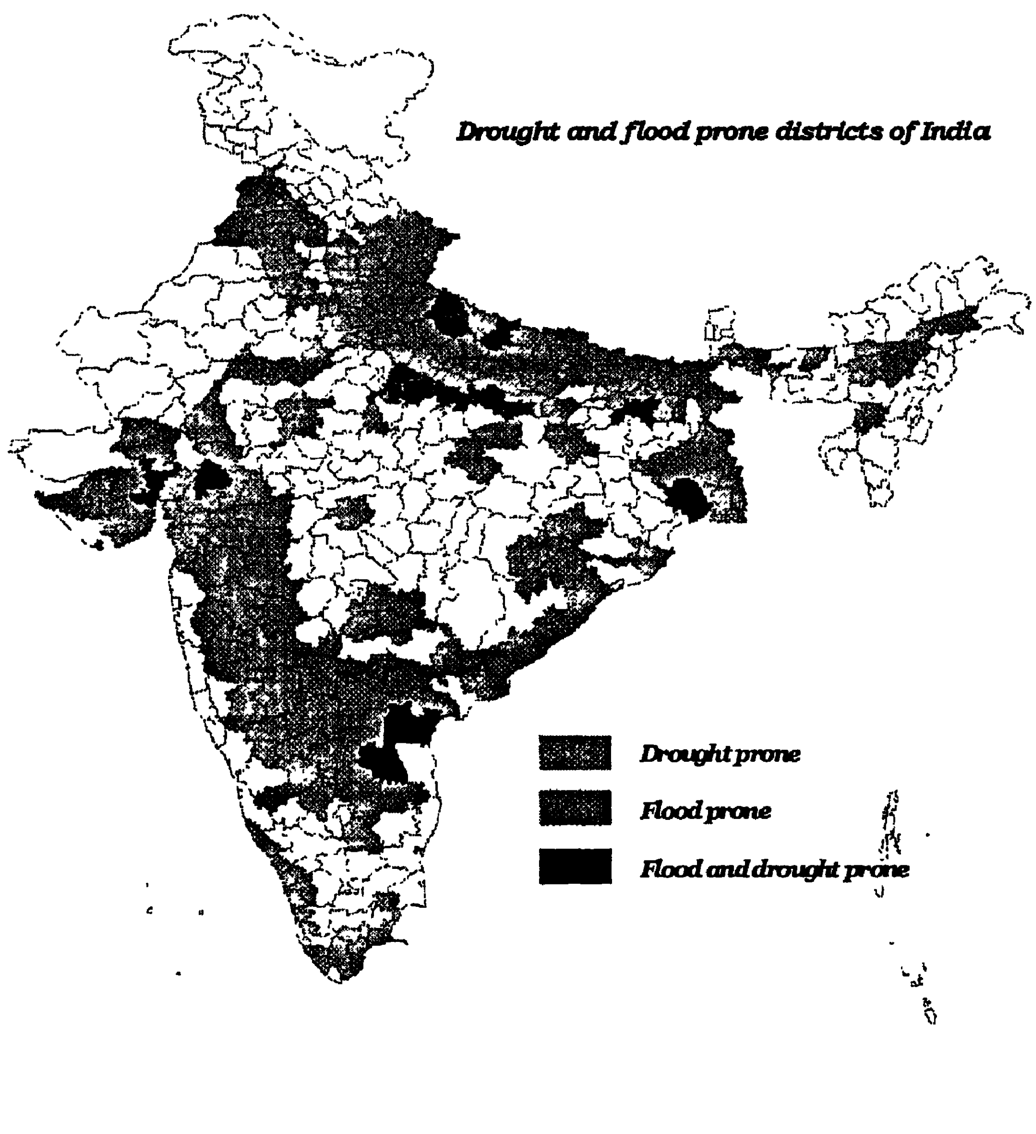


Figure 6. Drought prone and flood prone districts of India

Source: TERI GIS Database 2001 (based on data from Ground Water Statistics 1996 and Central Ground Water Board, Ministry of Water Resources)

India receives an annual precipitation of about 4000 billion cubic metres of which only 28.3 % can be utilised. The spatial and temporal distribution of rainfall is highly uneven, ranging from about 10 cm in Rajasthan to about 1000 cm in Cherrapunji. About one-third of the country is always under the threat of drought due to uneven distribution of rainfall (Figure 6).

Water consumption in India has been growing rapidly over the years (Figure 7). The agricultural sector accounts for nearly 93 % of the total water consumption in India. With a growing population the demand is likely to increase in other sectors as well. Moreover, the quality of surface and ground water resources has extensively declined over time, due to excessive discharge of effluents from various industries, over-use of agricultural fertilisers, mining and related activities, and bacterial contamination. Figure 8 illustrates the degree and nature of water stress experienced in different parts of the country. Thus the need to develop national level strategies to foster judicious management of both quantity as well as quality of water is essential at this stage for India.

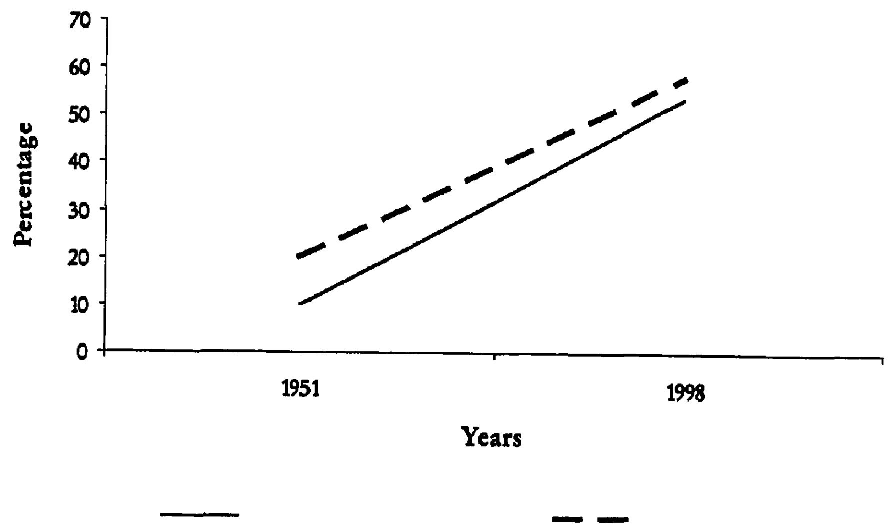
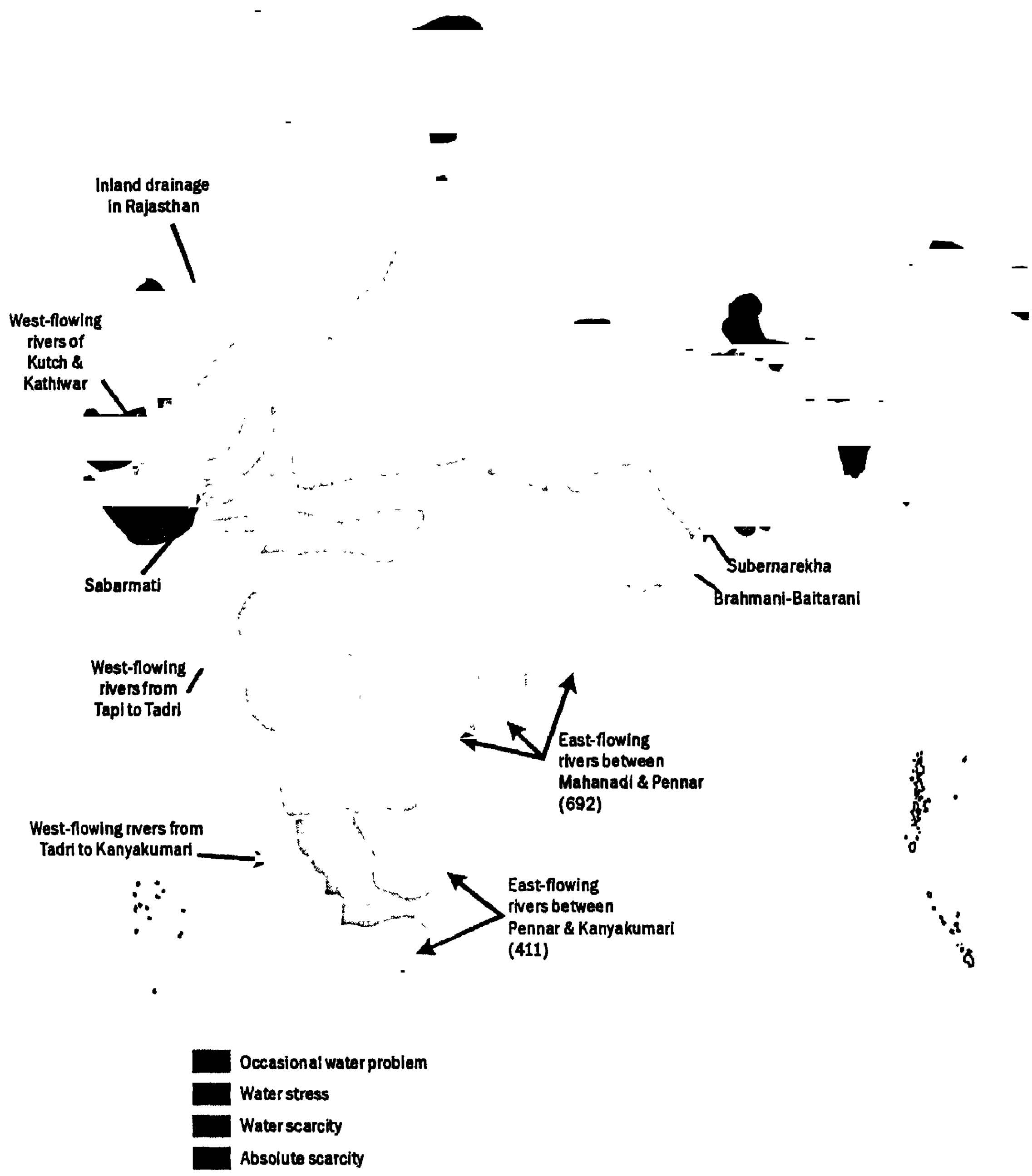


Figure 7. Actual utilisation of water in India (1951-1988)

Source: Environment and Water India (2000)

Figure 8. Degree and nature of water stress in India



Source: TERI GIS Database 2001 (based on Chitale (1992))

3.2 Government priorities and institutional framework

The importance of watershed development as a strategy of agricultural development in rainfed areas has been recognised in India for several years. The National Watershed Development Project for Rainfed Areas (NWDPRA) is promoted for a holistic approach towards conservation. The Ninth Five Year Plan (1997-2002) followed a regionally differentiated strategy for implementation of various plans, focusing on better water management practices, use of sprinkler systems to avoid water-logging, use of drip irrigation system optimizing usage of water in an efficient manner and addressing problems of salinity, development of efficient water harvesting methods and technologies, use of open-dug wells, tanks, or ponds which help in percolation of water at efficient rates, regular desilting and redigging of tanks, etc.

The Tenth Plan (2002-2007) envisages a major revival of public investment in irrigation capacity and water management. The plan talks of ground water development in the eastern regions of India to promote higher production from this region and calls for utilisation of more than one-fifth of the existing utilisation capacity. Further, it gives priority to promotion of agroforestry, conservation in mountainous areas, watershed development, river valley projects, plans in arid areas, and wasteland afforestation programmes.

The Ministry of Water Resources (MoWR) is responsible for all planning and developmental activities related to the water resources sector. The National Water Resources Council (NWRC) was set up by the Government of India in 1983 under the Chairmanship of the Prime Minister. The NWRC recommends policies, reviews plans submitted by agencies like the National Water Development Agency and River Basin Commissions. It also serves as an advisory board for resolving inter-state differences over implementation of projects, regulations for fair distribution and utilisation of water resources, etc. The National Water Board (NWB) was constituted in the year 1990 to review the implementation of the National Water Policy, and report to the NWRC. The

draft NWP (1998) was finalised by the NWB for further consideration by the NWRC. A Standing Committee was also formulated in 1996 in the MoWR for assessment of water for diverse uses in the country.

In India, while pressures have built up on water resources from a wide range of economic and developmental activities, the present policy and institutional framework has failed to ensure equity and sustainability in the use of water. Subsidies on power and water for irrigation have led to the over-usage and exploitation of water resources. Apart from this, water has been used extravagantly due to lack of rules that state a limit to the extraction of water. This indicates the absence of a well-defined system of property rights to water that stipulates limits to individual and collective withdrawals of water. Various schemes of the government have remained unsuccessful in terms of their operation due to reasons of poor maintainence, lack of accountability, domination by local bigwigs, frequent power cuts, delay in repairs, and other shortcomings (TERI 1998).

The current organizational set-up for water management is not so well defined at the central and state levels. Planning and implementation of surface water and ground water development programmes, and for the various sectors using water, are separate. This separation of functions discourages analysis of water and its use as a single resource. Water being a state subject empowers states to enact laws or frame policies but there has been no substantial progress in this regard at the state level (TERI 2000). Proper functioning of the NWRC to promote conservation programmes on a massive scale is required. There is a prime requisition for the formation of WUAs that handle inter-state disputes, water markets, public hearings, independence of EIAs, foster institutions that have the capacity to undertake local water management initiatives. More than structural changes in the institutions, a reorientation of attitudes is required that ensures effective inter-disciplinary functioning. Institutions should highlight the use of traditional systems and practices of water management for conservation of the resource in a sustainable manner. They should build on the capacity to work with the people and NGOs to draw on effective plans and policies for future (Iyer 2001).

3.3 Vulnerability to climate change

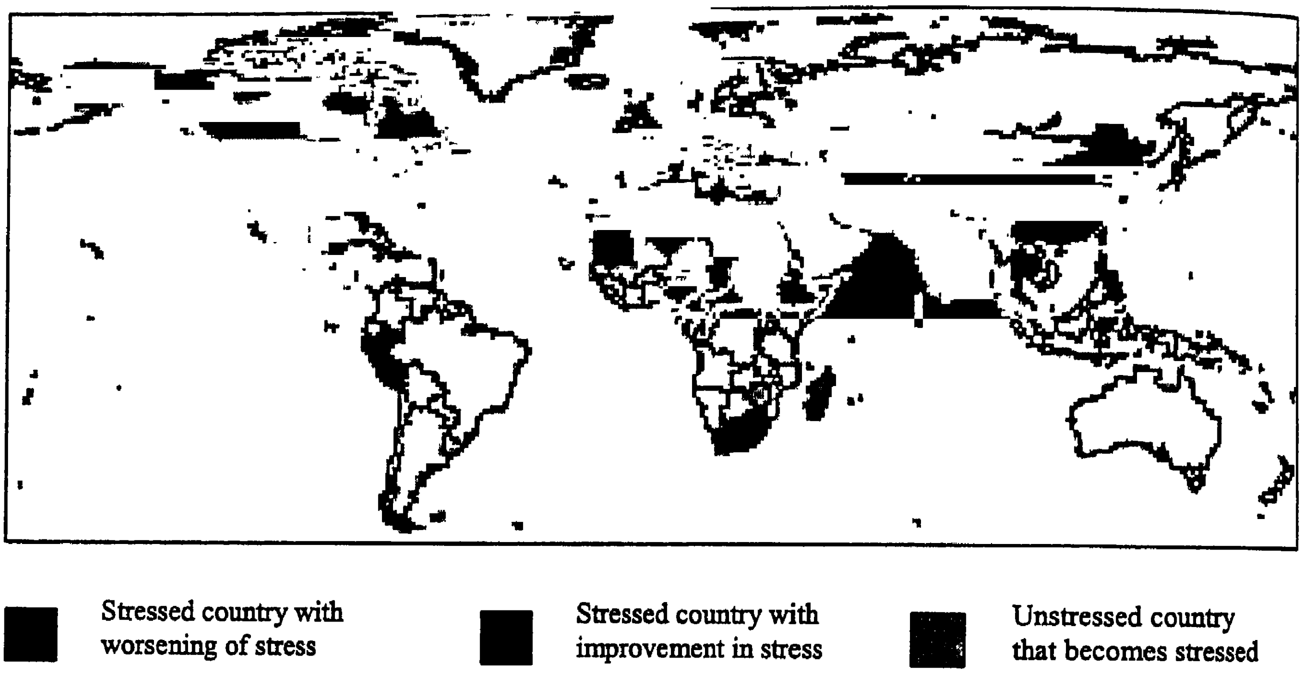


Figure 9. Impacts of climate change on water resources (in the 2080s with unmitigated emissions)

Source: DETR (1999)

The IPCC Third Assessment Report (IPCC 2001) projects a 1.4 – 5.8^{0}C rise in mean surface temperatures, 0.14 – 0.88 meter sea level rise, and precipitation changes on a global scale with substantial decreases or increases at the regional scale. The TAR scenarios indicate an increase in precipitation in southern Asia, with increased variability in the Asian summer monsoon. Sea level rise coupled with high precipitation events will increase coastal and inland flooding in many regions.

Though scenarios indicate an increase in precipitation over the region, several models indicate that many water-stressed countries[1] in the subtropical region will observe a decrease in water availability and reduced surface and groundwater recharge. IPCC

[1] Countries that are using more than 20 % of their renewable water supply at present. India is presently utilising 58% of its renewable water supply (Government of India 2001).

(2001) states with a high level of confidence that freshwater availability is expected to be highly vulnerable to anticipated climate change. In particular, surface run-off is expected to decrease drastically in arid and semi-arid Asia under projected climate change scenarios. Climate change is likely to change the volume as well as temporal distribution of streamflows.

According to the report, countries in which water use is more than 20% of total potential water resources available are expected to experience severe water stress during drought periods. Water would be a scarce commodity in many countries in south and south-east Asia, particularly where reservoir facilities to store water for irrigation are minimal. Population pressure will only serve to aggravate problems related to water availability and quality (IPCC 2001). The quality of water will also be affected drastically, with increased concentrations of pollutants in the water at low levels of dilution.

According to United Nations projections, India is projected to experience periodic or regular water stress by 2025, and is likely to cross the water scarce benchmark by the year 2050 under the high growth scenario. With climate change, it is predicted that there will be substantial decreases in the availability of water from rivers in the Indian subcontinent. This will worsen conditions as parts of India are already facing frequent droughts, and aggravate the stress faced by a rapidly developing economy with a large and growing population. As illustrated in Figure 9, India is one of the countries that are likely to experience a worsening of current water stress by the 2080s with unmitigated GHG emissions.

According to Lal (2001) there have been variations in rainfall distribution in some areas of the country in recent years. This includes a decrease in rainfall over east Madhya Pradesh, Orissa and northeast India and an increase along northwest India, west coast and north Andhra Pradesh. Although there is a high degree of uncertainty about future changes in the Indian monsoon, there is likely to be an increase in the year-to-year variability of monsoon rainfall. This would affect the replenishment of perennial rivers – for instance, the average annual runoff in the Brahmaputra river is projected to decline by

14% by 2050 (IPCC 2001). Non-perennial rivers in peninsular India will be affected to a greater extent – for instance, rivers such as Luni and Mahi occur seasonally and their existence depends on recharge by monsoon rainfall. In addition, temperature increase has resulted in retreat of major glaciers in the Himalayas, with available records suggesting that the Gangotri glacier is retreating at the rate of about 30 metres per year (Lal 2001). This is predicted to cause increased summer flows in some river systems for a few decades, followed by a reduction in flows as the glacier disappears (IPCC 1998).

The predominance of rainfed farming makes the primarily agricultural Indian economy highly vulnerable to climate change. Further, a rise in temperatures will require more intense irrigation, worsening the problem of groundwater extraction, and inadequate replenishment of aquifers. Other problems include sea water intrusion contaminating ground water reservoirs, which has decreased the quality of potable water in prime cities like Chennai and Mumbai. Fresh water bodies in many coastal areas such as the backwaters of Kerala, the Sunderbans of Bengal and the Chilka in Orissa have also been contaminated with saline influx from the sea.

4. Adaptation to climate change

The National Communication Support Programme (NCSP) of the UNDP-GEF has designed an **Adaptation Policy Framework** (APF) as a flexible guidance document for non-Annex I countries. According to this framework, the assessment of present and future vulnerability involves the following steps:

1. Examine the development policy context to ascertain how current policies incorporate climate risks and how different development paths may affect vulnerability to climate change.
2. Describe climate risks, including climate variability and extreme events.
3. Assess socioeconomic conditions, particularly in terms of adaptive capacity.
4. Establish links between climate change adaptation and natural resources and environmental management.
5. Determine losses (direct and indirect economic losses, mortality and morbidity, and environmental losses).
6. Identify adaptation policies and measures.

7. Specify constraints to adaptive capacity and means to strengthen it.

Adaptation itself can be viewed as a process with three stages[2]:
Stage I: Planning, which includes studies of possible impacts of climate change to identify particularly vulnerable countries or regions, and policy options for adaptation and appropriate capacity building.
Stage II: Measures, including further capacity building which may be taken to prepare for adaptation as envisaged in Article 4.1(e).
Stage III: Measures to facilitate adequate adaptation, including insurance and other adaptation measures as envisaged by Articles 4.1(b) and 4.4.

Adaptation measures must be **economically efficient, environmentally sustainable**, and help **advance social goals**. They can be classified into the following categories:

Adaptation category	Example
Bear costs	Accept the costs because it is the most effective choice or because there is no choice
Share losses	Relief and rehabilitation, insurance, community sharing, etc
Prevent or modify events	Flood control, irrigation projects, building dams, dykes, or flood control reservoirs, watershed treatment (including preserving or replanting forests to reduce peak flow downstream)
Prevent or modify impacts	Change human use activities e.g. regulate flood plain land use, flood-proof or elevated construction on flood-prone land, use drought tolerant crops, etc
Change use or location	Use flood plains for grazing land, parks, or wildlife instead of agriculture or housing, avoid expanding agriculture into unsustainable moisture-deficit regions
Research and/or restore	Study adaptation alternatives, identify new alternatives, restore sites where losses have occurred

Source: UNDP-GEF (2001)

4.1 Water conservation practices as adaptation measures

Adaptation to climate change in water resources can be undertaken on the supply side (modification of existing physical infrastructure, construction of new infrastructure, and alternative management of existing water supply systems) or on the demand side (conservation and improved efficiency, technological change, and market-driven transfers to other activities) (UNEP/IVM 1998).

The major impact of climate change in arid and semi-arid India is likely to be an acute shortage of water resources associated with significant increases in surface air temperature. Conservation of water used for irrigated agriculture, needs to be given priority attention. Other related options are protection of soil from degradation, introduction of low water-use crops, implementation of groundwater protection programmes. Such options are part of autonomous adaptation, or changes in agriculture, water resources, etc that individuals or communities undertake in order to adjust to past or ongoing changes (whether extreme climatic events or in response to increased demand). Many demand-side interventions (e.g. improving irrigation use efficiency) and supply-side options (e.g. increasing irrigation source capacity) have been implemented or tested within the framework of development activities. These management strategies are also potentially feasible in the face of climate change, which represents an additional pressure on water resources (IPCC 2001).

This report focuses mainly on the linkages with and implications for agriculture given its overwhelming share in water consumption in India. Various traditional methods for water conservation have been in use in water-scarce parts of India. However, over the period 1951-93, land under traditional irrigation declined by more than 3 million hectares. These traditional methods are suited to the environments in which they have evolved, and can be encouraged as potential adaptation options that promote conservation as well as efficient utilisation of the resource.

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[2] Initial Guidance from the Conference of the Parties on Adaptation (Decision 11/CP.1)

An excellent example of this was set in Baloda Lakha village in Madhya Pradesh. The villagers of this village have managed to change the drought like conditions that prevailed in the region. These people took the effort to invest privately from their own earnings to build scores of water-bunds, ponds, tanks, and village-style roof water harvesting structures across the village for capturing rainwater. They desilted old tanks, repaired old wells and recharged wells through underground pipes from the water conserved in nullah-bunds. All these practices for conserving water resulted in the rise of ground water levels substantially in the region and the village now has enough water to be utilised for various purposes including irrigation.

4.2 Ongoing interventions in water resources in India: Case studies

(a) Micro-credit operations in Lakkenahally watershed

Lakkenahally micro-watershed covers 210 acres divided by ravines into three micro-catchments. This land was owned by 62 families and was vulnerable to floods. Crops were often washed away, and many fields had not been cultivated for several years.

In 1991, three Credit Management Groups (CMG) were formed with a total membership of 54. A Watershed Development Association (WDA) was also established in 1992. One of the CMGs was a women's group with 14 members. These were small, homogenous, voluntary, and autonomous groups that mobilized savings. They developed their own rules and regulations governing the purpose and size of loans, interest rates, schedules of recovery, and sanctions. They provided credit and group support to help their members meet their livelihood needs, e.g. by providing loans for various forms of consumption, small business and cottage industries (Fernandez 1993).

The main problems faced by farmers were erratic rainfall, low moisture holding capacity of soils, and declining productivity. As part of a collective exercise, 75 farmers (including 35 women) outlined a plan of action, and agreed on the contribution towards the costs of the activities. The following activities were taken up on a priority basis (Fernandez 1993):

1. Construction of silt traps to build up adequate soil in areas with high water storage potential. The improved water holding capacity would reduce the risk of crop failure in these areas. Farmers who cultivate lands in the tank bed downstream would also benefit in terms of reduced damage by floods rushing through the ravine.
2. Excavation of small open wells near reclaimed areas. This provided farmers with protective irrigation, and they were able to introduce a paddy crop.
3. Wasteland development was taken up on 16 acres of land. This included regeneration of a hillock, with farmers working at lower wages to construct protection walls and plant saplings around the hillock. The grasses were harvested and sold locally by the credit group, indicating the sustainability of the exercise.

Hence, this approach combines different categories of adaptation options viz. prevention and modification of impacts and events, and changes in use.

(b) Tank rehabilitation in Rajasthan

Rajasthan has 4600 minor irrigation tanks, many of which are several decades old. Typically these have earthen dams with a pucca overflow structure and one or more sluices, leading to canals with pipe outlets for irrigation. The benefits of this minor irrigation tank system include:

- They help capture and store the meager rainfall received by the region
- They help reduce soil erosion by stemming water flow
- They provide low cost irrigation
- They help recharge ground water aquifers, which are sources of irrigation and domestic water supply
- They reduce the damage from flash flood in high rainfall years.

The minor tank irrigation system in Rajasthan had fallen into disrepair over the years, with siltation of tank beds and inefficiencies in the canal distribution system. Gradual expansion of the command area and catchment encroachment were associated problems. The need was for management rehabilitation of tanks, by instituting social and

organizational processes that would induce users to take responsibility for managing the system on a viable and sustainable basis (Raju and Shah 1997).

This need was addressed by involving all relevant stakeholders, including command area farmers, groundwater users, downstream water harvesters, fish culturists, pastoralists, non-agricultural users, domestic users, and women, and locally active NGOs. Farmer participation was ensured by starting with low cost, high payoff repair works, and then building up to more expensive items of engineering. This involved a three-year exercise of complete management rehabilitation of 1198 minor irrigation tanks, with a 24-month pilot and preparatory phase covering 50 minor irrigation tanks (Raju and Shah 1997).

This approach can be categorized as prevention or modification of events, and the manner in which it was undertaken, viz. through community sharing and participation is similar to the 'share losses' category.

(c) Rainwater harvesting in Chhotanagpur region

The Chhotanagpur plateau covers the southern parts of Bihar, Orissa, and West Bengal. Its arable land has been classified into three parts:

- Uplands with red lateritic shallow soils, low humus and nutrient content, and mostly barren land. The land is highly degraded, and supports low intensity cropping with low productivity.
- Midlands with sandy shallow soils, and poor moisture retention. The land supports terraced rice fields, but mid season droughts[3] occur every 2-3 years resulting in crop failure.
- Lowlands with sandy loam soils, where paddy is grown.

In consultation with local people and NGOs, a range of rainwater harvesting techniques was introduced to enhance the soil and moisture regime in the area (Myrada and IRRA 1997):

[3] particularly in September, during the period of flowering and grain formation.

- Staggered trenching - Trenches were excavated on sloping land to prevent runoff and erosion. These were interspaced with the pile of excavated soil, on which trees and grasses were planted.
- Upland treatment – The land was bunded into rectangular plots, and pits were dug at the lowest corner of the plots. The excavated soil was used to prepare bunds that were planted with trees and grasses. This helped in arresting runoff and soil erosion, conserving rainwater in situ, and recharging the soil profile.
- Midland treatment – 5% of the area of each agricultural plot was excavated at its lowest point to a depth of about 1 m. These pits harvested rainwater and also collected sub-surface seepage, reducing the moisture stress on the rice crop.

The adoption of these techniques had the following benefits:

- Growth of trees, shrubs, and grasses on barren and eroded uplands
- Provision of subsistence needs for fuel, fodder, fibre, and timber
- Income generation from sale of excess produce
- Prevention of outright loss of rice crop
- Improvement of rice yield due to soil moisture conservation
- Use of pits in treated midlands for pisciculture for subsistence.

Each of the adopted techniques was able to pay for itself within a few years, indicating the economic sustainability of this approach. Over the period 1992-96, 63 villages were covered, benefiting 1040 households (Myrada and IRRA 1997).

Hence, this approach involves a combination of prevention and modification of events and impacts, changed use as well as restoration.

4.3 Cross-cutting issues

Each of the interventions reviewed yielded multiple benefits related to sectors such as agriculture, livestock, fisheries, forestry, etc, reinforcing the win-win nature of these options. While these options were undertaken to address current pressures, they are important means of responding to the challenge of climate change.

As discussed in section 5.1, vulnerability to climate change must be examined in the context of other pressures or changes that affect water resources and other related factors. As such climate change represents an additional factor that must be taken into consideration in outlining appropriate water management policies and practices. Ongoing interventions and existing policies have significant potential as adaptation strategies. However, given the uncertain and non-linear nature of the potential impacts of climate change, what is required is a new approach to selecting and implementing these known strategies.

There is a need for an integrated approach to water resources management, which explicitly considers all potential supply-side and demand-side options, includes all relevant stakeholders in the decision-making process, and involves continuous monitoring of the water resources situation (IPCC 2001). This is a no-regrets approach that would be beneficial even in the absence of climate change, but will further strengthen the capacity to cope with the impacts of climate change.

5. Concluding remarks: research questions and follow-up activities

Climate change could have a major impact on water supply and demand. There have been some studies to estimate the potential impact of climate change on water resources. However, there is a need to review water policy or planning principles, and ongoing interventions to assess how these should incorporate adaptation to climate change impacts.

India should identify and provide detailed information through its national communication on the country's needs and concerns arising from the adverse impacts of climate change. It should also mobilize existing national institutions and build on existing endogenous capacities, traditional skills, knowledge and practices. By identifying its specific V&A capacity building priorities, the country can seek financial support from the funds established under the Bonn agreement, as well as other bilateral and multilateral

sources. This approach should involve a wide range of stakeholders, including national and local government bodies, civil society, private sector, and other organizations.

There is a need for an integrated approach to water resources management (IPCC 2001)

- Explicitly considering all potential supply-side and demand-side options
- Including all stakeholders in the decision-making process
- Continually monitoring the water resources situation.

This is a no-regrets approach that would be beneficial even in the absence of climate change, but will further strengthen the capacity to cope with the impacts of climate change.

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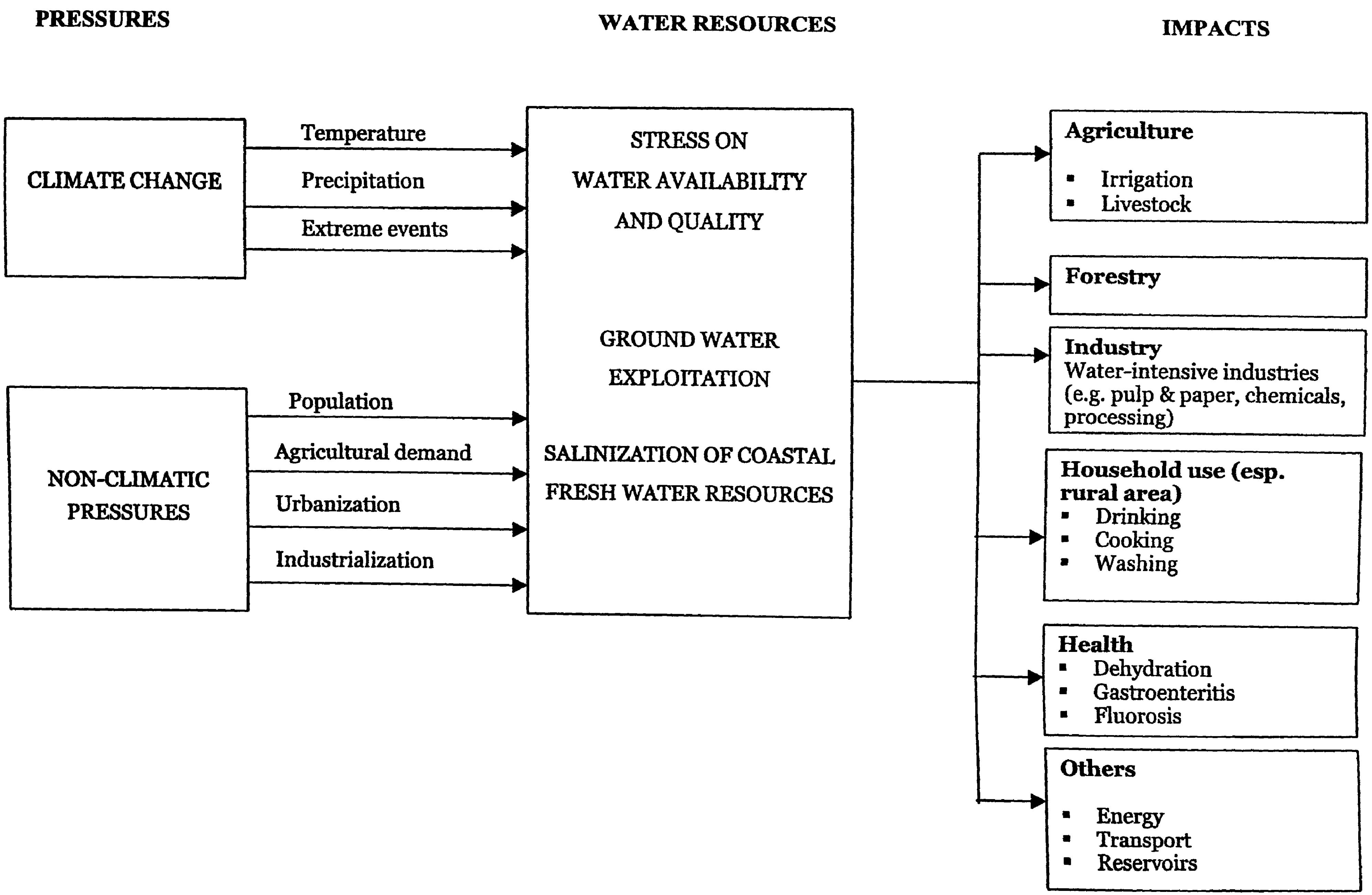
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